



The International Forum to Advance First Responder Innovation

Capability Gap 3 “Deep Dive” Analysis Synopsis

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**International Forum to Advance
FIRST RESPONDER INNOVATION**

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This document has been checked for accuracy by the International Forum to Advance First Responder Innovation and accords with our aims to inform and guide industry and provide unbiased information on first responder technologies. However, the views and conclusions contained herein are those of the authors and should not be interpreted as necessarily representing the official policies either expressed or implied by the Forum. While this material has been through a Forum quality assurance process, the Forum does not accept responsibility for the content contained herein.

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Introduction

This analysis activity intends to characterize markets and identify technology solutions relevant to the International Forum to Advance First Responder Innovation's (Forum) Common Global Capability Gaps List, to garner interest from researchers in industry and academia to develop affordable and innovative technology solutions addressing the various capability gaps for first responders. This publication represents a summary of analysis activity for **Capability Gap 3—The Ability to Rapidly Identify Hazardous Agents and Contaminants**. It is anticipated that the remaining capability gap will be analyzed and published in a similar fashion.

Forum Background

Established in 2014, the Forum is an organization of government leaders from across the globe, focused on enhancing and expanding the development of affordable and innovative technology for first responders worldwide.

In order to respond more safely, efficiently and effectively to everyday and catastrophic emergencies, first responders around the globe need technologically advanced tools and equipment that are affordable and innovative. However, there is no centralized mechanism for responders to identify and discuss shared needs and requirements. In addition, overall purchasing of tools and equipment is fragmented into smaller quantities, which provides little incentive for industry to commercialize innovative technologies. Therefore, the lack of consolidated requirements for first responders, along with fragmented purchasing, results in an inadequate amount of affordable new technology being available. This leads to an insufficient amount of research and development (R&D) being conducted in the first responder market.

The Forum addresses this challenge by:

1. Working with the global first responder community to define a list of common, high priority capability gaps.
2. Providing a platform for international collaboration on innovative R&D initiatives and solutions.
3. Characterizing global first responder markets, to inform and guide industry and academia about market opportunities and to incentivize them to develop and produce innovative technology solutions to capability gaps.
4. Providing information about relevant and available first responder technologies to the first responder community, while not endorsing any specific technology, product or manufacturer.

Forum Membership

The Forum is currently composed of members from 13 different countries and the European Commission (EC), including Australia, Canada, Finland, Germany, Israel, Japan, the Netherlands, New Zealand, Singapore, Spain, Sweden, the United Kingdom and the United States. France and Mexico's participation in the Forum is pending.



Common Global Capability Gaps List Background

In 2016, the Forum agreed to a Common Global Capability Gaps list, presented below:

- Capability Gap 1** The ability to know the location of responders and their proximity to risks and hazards in real time
- Capability Gap 2** The ability to detect, monitor and analyze passive and active threats and hazards at incident scenes in real time
- Capability Gap 3** The ability to rapidly identify hazardous agents and contaminants
- Capability Gap 4** The ability to incorporate information from multiple and nontraditional sources (e.g. crowdsourcing and social media) into incident command operations

To arrive at this initial set of gaps, Forum participants conducted analyses of first responder capability gaps in their countries. Some of the Forum participants used the methodology presented in the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) Project Responder 4 (PR4) report, as a guide in their gap analyses. PR4 is the fourth in a series of studies that started in 2003 to focus on identifying capability needs, shortfalls and priorities for catastrophic incident response. The methodology is based upon discussions with federal, state and local first responders as well as technical subject matter experts.

After submission of gaps from Forum participants, a comparative analysis of all submitted gaps was conducted. The analysis found a significant level of overlap among the various countries' gaps, which resulted in the proposal and adoption of the Forum's Common Global Capability Gaps List. This publication represents a general characterization of the global industries and market trends, specifically regarding potential solutions to Capability Gap 3. The purpose for analyzing and presenting this data is to identify potential areas of R&D where there may be opportunity for industry and academia to market an innovative solution. It is anticipated that the remaining two gaps will be analyzed in a similar fashion. The following table presents the status of current and future Capability Gap "Deep Dive" Analyses publications:

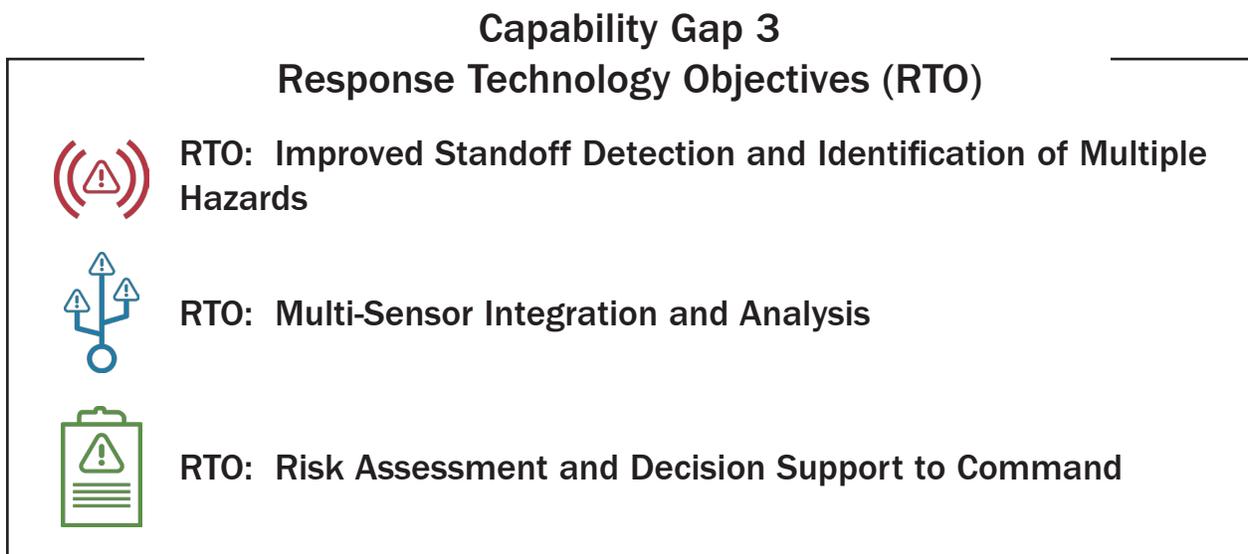
Capability Gap "Deep Dive" Analyses: Current and Future Publications	
Capability Gap 1	Published January 2017
Capability Gap 2	Published September 2017
Capability Gap 3	Published September 2017
Capability Gap 4	To be published in 2018

Capability Gap 3

The definition of Capability Gap 3 is **the ability to rapidly identify hazardous agents and contaminants**. This capability gap involves the development of responder-specific identification, detection and analysis solutions to enhance situational awareness at incident scenes. These solutions may also include subsequent software or devices enabled to display data and analysis on an intuitive user interface.

As Forum participants examined gaps within their countries, first responders consistently stated there is a need to rapidly identify, detect and analyze threats and hazards. More specifically, in order to improve responder safety, efficiency and effectiveness, responders need the ability to rapidly identify hazardous agents and contaminants at safe distances. During an incident, first responders may be unknowingly exposed to a range of threats, including hazardous agents and contaminants. The ability to rapidly identify hazardous agents and contaminants, and understand pertinent information regarding protective actions or treatments for these threats, is likely to improve response situational awareness and decision-making.

This analysis uses the Response Technology Objectives (RTOs) identified in PR4 as a starting point for further defining and segmenting Capability Gap 3. As stated in the PR4 report, RTOs translate capability statements or needs into actionable, technology-centric objectives. Each RTO identifies a high-level technology solution (or part of a solution) designed to improve the capabilities of the response community. Capability Gap 3 consists of three corresponding RTOs, presented below:



*Further definitions of these RTOs are provided in the Glossary.

Methodology

The following section provides a brief overview of the processes used to obtain and assess the findings presented in this synopsis.

Objective

The key objective of this analysis activity is to characterize the markets relevant to Capability Gap 3, to garner interest from researchers in industry and academia to develop affordable, innovative technology addressing the gap for responders. In other words, it is intended that this information will serve to inform and guide research and development efforts, supporting the overall goals of the Forum.

Research Methods

Data presented in this report was gathered primarily using secondary research methodologies. Research consisted of gathering publicly available information from various sources including market reports and company Web sites, among others. Secondary research methodologies were chosen for this analysis because information gathered using primary research would likely have been proprietary in nature and therefore not suitable for publishing. With that in mind, data presented in this report should not be considered exhaustive. Furthermore, regarding potential solutions, this analysis relies upon information that is publicly available from manufacturers' Web sites, but it does not validate the claims made thereon.

Market Definition and Segmentation

This analysis uses the Response Technology Objectives (RTOs) developed by PR4 as a starting point for further defining and segmenting Capability Gap 3. More specifically, relevant market segments for each RTO were identified through secondary research, with primary markets being identified for each one.

Market Quantification

All relevant markets are quantified utilizing overall revenue figures for the forecast period 2015 to 2020. The Compound Annual Growth Rate (CAGR) within each segment is used to measure growth within the forecast period and to extrapolate data when figures were not publicly available. As the first responder segments of these relevant markets appear to be underdeveloped, overarching market figures are present. Data for the primary markets is used in the aggregated findings presented in the body of this report.

Market Phase and Factors

Market phase is determined using factors in the Industry Life Cycle model. The adapted market phase definitions are as follows:

Nascent	New market need with dominant solutions not yet determined, growth begins increasing toward end of cycle
Growth	Dominant solutions begin to emerge, high growth rates
Mature	Typically fewer firms than growth phase, as dominant solutions continue to capture the majority of market share and market consolidation occurs, lower growth rates that are typically on par with the general economy
Decline	Further market consolidation, rapidly declining growth rates

Market factors are assessed by examining barriers to entry and market opportunities, as determined through secondary research.

Competitive Landscape

This analysis also examines the competitive landscape within each market, accounting for the total number of firms, along with the number of responder-specific solutions. Total number of firms was estimated using the number of key players given within publicly available market reports for each segment, while responder-specific solutions were identified using a more tailored search. This search included examining the key players listed by the publicly available market reports and conducting targeted keyword searches for solutions from companies not mentioned in these reports.

Dominant Solutions

Dominant solutions are determined by examining market share breakdown. Solutions capturing the majority of the market share are considered to be dominant.

Presentation

This synopsis begins by presenting a *Market Overview* that summarizes the overall market and provides the market quantification data for each segment. It then presents the key findings for each market segment in the *Market Highlights* section, with a one-page summary for each segment. Finally, the *Technology Landscape* section further categorizes the total number of firms participating in the market by segment and highlights responder-specific solutions available or in development.

Synopsis Overview

In order to meet its objectives of defining and publishing a global set of capability gaps and informing and guiding industry, the Forum has been conducting an ongoing global capability gaps market analysis. The key objective of this analysis activity is to characterize the markets relevant to Capability Gap 3, to garner interest from researchers in academia and industry to develop affordable, innovative technology addressing the gap for responders. This synopsis represents a summary of this activity to date.



Capability Gap 3

The ability to rapidly identify hazardous agents and contaminants

Market Definitions and Segmentation

This analysis activity begins by defining and segmenting the relevant markets for each Response Technology Objective (RTO) within Capability Gap 3. A primary market is identified for each RTO and is used for market quantification. Each RTO and its corresponding primary market is presented below:

Market Definitions and Segmentation

Response Technology Objective (RTO):

Primary Market(s):



Improved Standoff Detection and Identification of Multiple Hazards

Threat Detection Systems Market



Multi-Sensor Integration and Analysis

Smart Sensors Market



Risk Assessment and Decision Support to Command

Situational Awareness Systems Market

*Further definitions of these RTOs are provided in the Glossary.

Market Quantification

Each market, both primary and secondary, is quantified utilizing overall revenue figures. Growth is measured using Compound Annual Growth Rate (CAGR). In this analysis, it was found that the identified primary markets accounted for approximately **\$84.9 billion in revenue in 2015**.

Competitive Landscape

In this analysis activity, it was found that there are 46 key global players within the primary markets identified for Capability Gap 3. These key global players appear to offer solutions that address, in part, the ability to rapidly identify hazardous agents and contaminants for a variety of industry verticals, including public safety and first responders. There appears to be an opportunity for these key global players to advance or adapt their solutions to further meet the needs of first responders. By engaging with responders, particularly on a global level through the Forum, firms can begin to further assess how close they are to providing meaningful solutions for responders.

Dominant Solutions, Market Factors and Market Phase

The aspects of each market, which include dominant solutions, market factors and market phase are summarized within the *Market Highlights* section of this synopsis. It appears that each primary market relevant to Capability Gap 3 has a similar market phase, with the existence of a dominant solution. However, despite the maturity of these markets, there appears to be an opportunity to advance the existing solutions offered in the markets with emerging, innovative technology, in order to further meet the needs of first responders. Thus, each market phase is categorized as “Mature + Growth” because some subsegments of the market appear to be mature, while other subsegments appear to be in the growth phase.

Summary

Overall, there appears to be a number of key global players working on and providing solutions for first responders and other end users to rapidly identify hazardous agents and contaminants. However, these solutions appear to vary in their ability to meet the full spectrum of first responder needs and requirements for Capability Gap 3. Therefore, in general, there may be a potential opportunity for firms to adapt or advance their solutions to meet the dynamic needs of first responders.

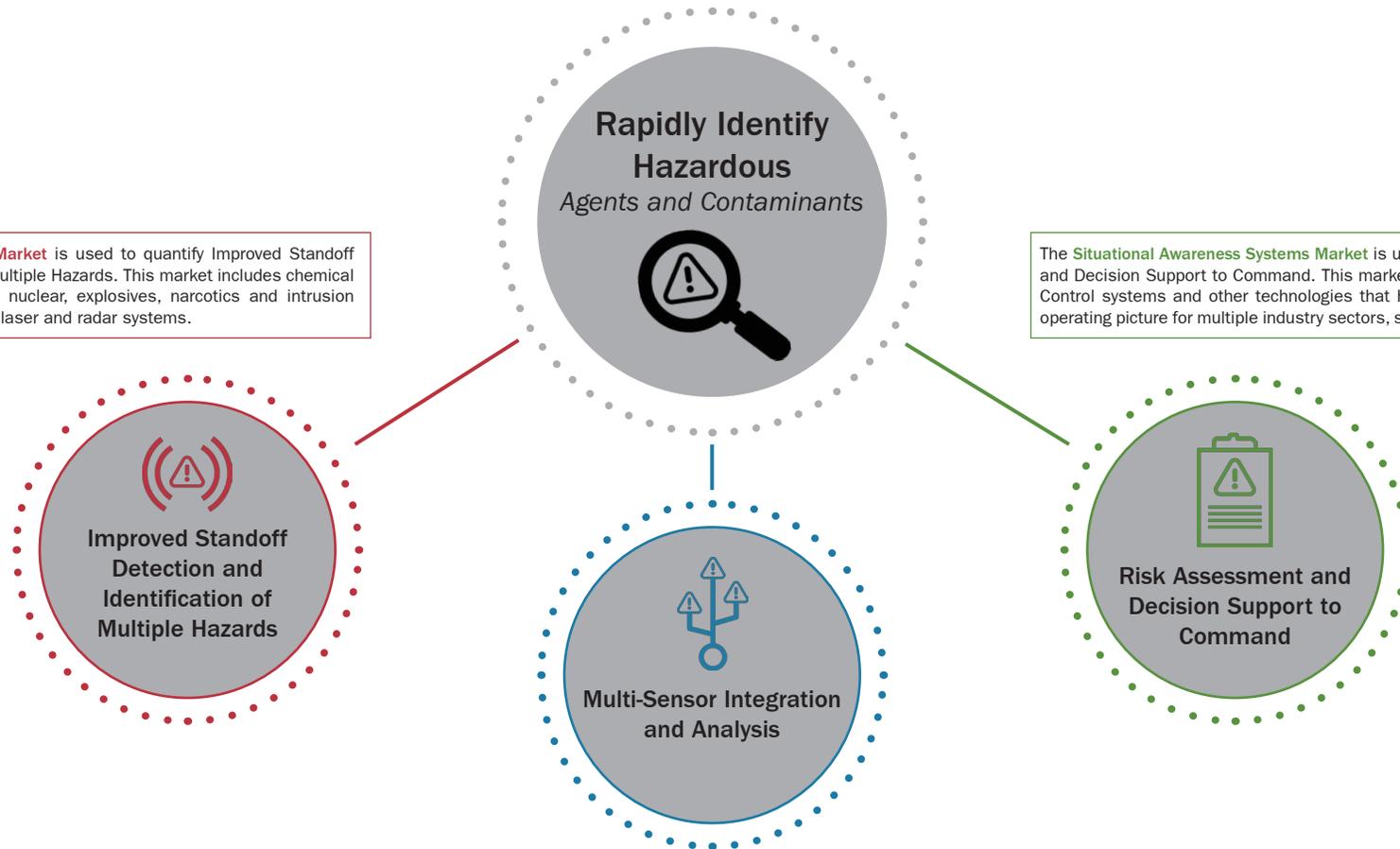
This opportunity appears to align with the current phase of the markets examined in this assessment. Each of the primary markets appears to have reached a period of potential innovation, during which improvement to current capabilities will be encouraged. Solutions that exhaust or replicate current capabilities are not expected to thrive in the market. Firms that provide new and innovative technologies that enhance existing capabilities of current or matured solutions will likely experience the greatest market opportunity. The factors impacting the ability to capture these opportunities varies by market, which are addressed in the following sections within this synopsis.

Market Overview

Market Definition

Capability Gap 3 is defined as **the ability to rapidly identify hazardous agents and contaminants**. The figure below presents the overarching segmentation of the markets relevant to Capability Gap 3, as identified in this analysis:

Market Segmentation



The **Threat Detection Systems Market** is used to quantify Improved Standoff Detection and Identification of Multiple Hazards. This market includes chemical and biological, radiological and nuclear, explosives, narcotics and intrusion detection technologies, such as laser and radar systems.

The **Situational Awareness Systems Market** is used to quantify Risk Assessment and Decision Support to Command. This market is composed of Command and Control systems and other technologies that help to provide a comprehensive operating picture for multiple industry sectors, such as public safety and security.

The **Smart Sensors Market** is used to quantify Multi-Sensor Integration and Analysis. This market includes multiple types of sensing technologies, including integrated smart sensors. The rising trend of sensor miniaturization is expected to advance the growth of this market.

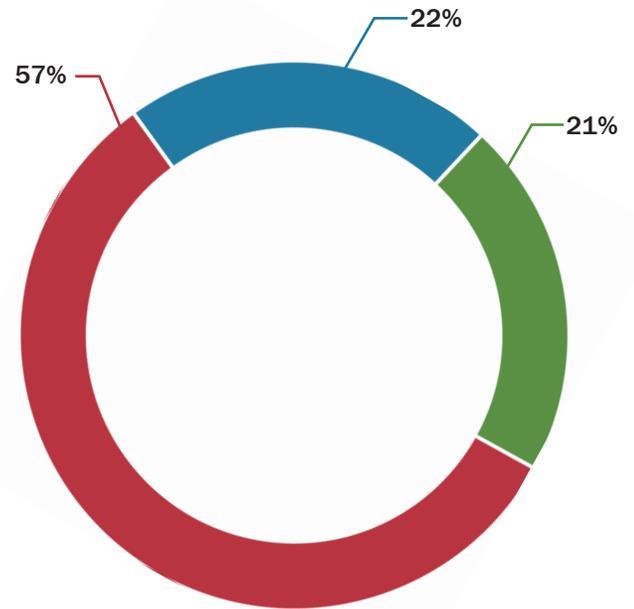
Capability Gap 3 - The Ability to Rapidly Identify Hazardous Agents and Contaminants

During an incident, first responders may be unknowingly exposed to a range of threats, including hazardous agents and contaminants. In order to improve responder safety, efficiency and effectiveness, responders need the ability to rapidly identify hazardous agents and contaminants at safe distances. The ability to rapidly identify hazardous agents and contaminants, and to understand pertinent information regarding protective actions or treatments for these threats, is likely to improve response situational awareness and decision-making.

A myriad of identification, detection and analysis solutions currently exist within the market. However, there appears to be a limited number of technologies that address multiple responder needs on an integrated platform, or are suitable for enhanced first responder use.

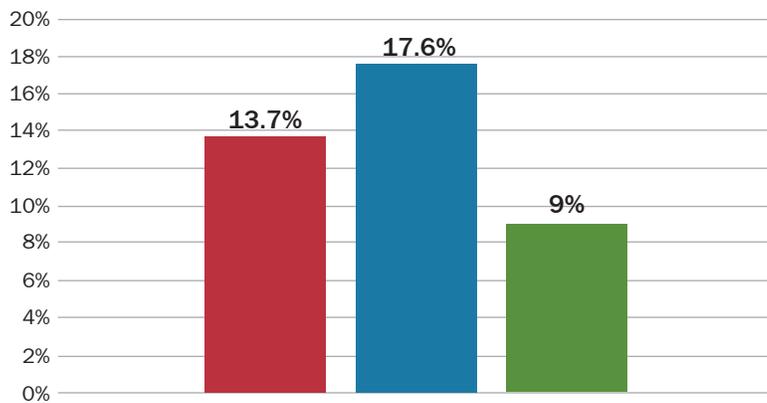
Among the market segments to rapidly identify hazardous agents and contaminants, Multi-Sensor Integration and Analysis is expected to grow at the highest compound annual growth rate (CAGR) of 17.6 percent during the forecast period of 2015 to 2020, followed by Improved Standoff Detection and Identification of Multiple Hazards at 13.7 percent and Risk Assessment and Decision Support to Command at 9 percent.

In 2015, the market for Improved Standoff Detection and Identification of Multiple Hazards captured 57 percent of the market, followed by Multi-Sensor Integration and Analysis at 22 percent and Risk Assessment and Decision Support to Command at 21 percent.



Rapid Identification of Hazardous Agents and Contaminants, 2015

- Improved Standoff Detection and Identification of Multiple Hazards
- Multi-Sensor Integration and Analysis
- Risk Assessment and Decision Support to Command



Rapid Identification of Hazardous Agents and Contaminants CAGR, 2015 to 2020

- Improved Standoff Detection and Identification of Multiple Hazards
- Multi-Sensor Integration and Analysis
- Risk Assessment and Decision Support to Command

Market Figures

The following tables present the estimated revenue figures for the various sub-markets identified for each RTO segment within the Capability Gap 3 market. The figures in the colored rows represent the primary markets used to quantify each segment in this analysis activity.

Disclaimer

All figures have been rounded to the nearest hundred thousand. The market forecast period examined is 2015 to 2020. When a market value was not available, it was estimated using the corresponding CAGR given over the forecast period 2015 to 2020 to represent growth or decline.

For consistency, data that fell outside of the forecast period 2015 to 2020 has been extrapolated, as denoted by an asterisk (*). A more detailed explanation of how the extrapolated figures were estimated can be found in the Appendix at the end of this synopsis.

Improved Standoff Detection and Identification of Multiple Hazards

	Revenue by Year (in \$1,000,000)						CAGR
	2015	2016	2017	2018	2019	2020	
Threat Detection Systems Market	\$48,400	\$55,000	\$62,600	\$71,200	\$81,000	\$92,100	13.7%
Chemical, Biological, Radiological, Nuclear and Explosives (CBRNE) Detection Market	\$2,200	\$3,000	\$4,000	\$5,400	\$7,300	\$9,800	34.8%
Chemical Sensors Market	\$16,100	\$17,500	\$18,900	\$20,500	\$22,000	\$23,700	8%
Biodefense Market	\$9,700	\$10,300	\$11,000	\$11,700	\$12,400	\$13,200	6.4%
Biodefense-Related Rapid Pathogen Identification and Treatments (U.S.) Market	\$214.2	\$248	\$267.8	\$289.1	\$312.2	\$337.1	9.5%
Market Segment: Detection Devices	\$146.9*	\$155	\$163.1	\$171.6	\$180.6	\$190.1	5.3%
Market Segment: Sensors Devices	\$81.8*	\$93	\$104.2	\$116.7	\$130.7	\$146.4	12.3%
Digital Scent Technology Market	\$199.9	\$256.2	\$328.3	\$420.8	\$539.2	\$691	28.2%

Improved Standoff Detection and Identification of Multiple Hazards (Continued)

	Revenue by Year (in \$1,000,000)						CAGR
	2015	2016	2017	2018	2019	2020	
Portable Gas Detectors Market	\$1,100	\$1,100	\$1,200	\$1,200	\$1,300	\$1,300	3.4%
Market Segment: Fire Services	\$31.9	\$34.7	\$37.8	\$41.2	\$44.9	\$48.9	8.9%
Volatile Organic Compound (VOC) Gas Detectors Market	\$127*	\$131.7	\$135.8	\$140.3	\$144.9	\$149.7	3.3%
Market Segment: Active Collection	\$80.7*	\$83.5	\$86.3	\$89.2	\$92.2	\$95.3	3.4%
Market Segment: Passive Collection	\$46.3*	\$47.9	\$49.5	\$51.1	\$52.7	\$54.4	3.3%
Explosive Detectors Market	\$3,600	\$4,000	\$4,400	\$4,900	\$5,500	\$6,100	11.1%
Spectroscopy Equipment Market	\$13,500	\$13,900	\$14,300	\$14,700	\$15,200	\$15,600	2.9%
Infrared (IR) Spectroscopy Market	\$874.3	\$939.1	\$1,000	\$1,100	\$1,200	\$1,300	8.3%
Raman Spectroscopy Market	\$986.1	\$1,100	\$1,200	\$1,300	\$1,500	\$1,600	10.2%
Terahertz Spectroscopy Market	\$20	\$24.3	\$29.4	\$35.7	\$43.3	\$52.5	21.3%

Multi-Sensor Integration and Analysis

	Revenue by Year (in \$1,000,000)						CAGR
	2015	2016	2017	2018	2019	2020	
Smart Sensors Market	\$18,600	\$21,800	\$25,700	\$30,200	\$35,500	\$41,800	17.6%
Sensors for the Internet of Things (IoT) Market	\$3,300	\$4,700	\$6,700	\$9,500	\$13,500	\$19,100	42.1%
Multi-Sensor Market	\$80.4	\$86.5	\$93	\$100	\$107*	\$114.5*	7.3%
Microelectromechanical Systems (MEMS) Market	\$12,800	\$14,300	\$15,900	\$17,700	\$19,700	\$21,900	11.3%
Nanosensors Market	\$47.8	\$84.9	\$150.8	\$267.8	\$475.7	\$845	77.6%
Microsensors Market	\$10,900	\$12,200	\$13,600	\$15,200	\$16,900	\$18,900	11.6%
Market Segment: MEMS Sensors	\$6,400	\$6,900	\$7,500	\$8,200	\$8,900	\$9,600	8.4%
Market Segment: Biochips	\$4,000	\$4,700	\$5,500	\$6,400	\$7,400	\$8,700	16.8%

Risk Assessment and Decision Support to Command

	Revenue by Year (in \$1,000,000)						CAGR
	2015	2016	2017	2018	2019	2020	
Situational Awareness Systems Market	\$17,900	\$19,500	\$21,300	\$23,200	\$25,200	\$27,500	9%
Command, Control and Intelligence (C2/C4ISR) Market	\$18,200	\$18,800	\$19,400	\$19,900	\$20,500	\$21,200	3.1%
Command and Control (C2) Market	\$13,800	\$14,300	\$14,800	\$15,300	\$15,900	\$16,500	3.6%
Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) Market	\$90,600*	\$93,800	\$97,000	\$100,300	\$103,600	\$107,200	3.4%
First Responder Command and Control, Communications (C3I) and Emergency Response Market	\$76,100	\$87,200	\$100,100	\$114,800	\$131,600	\$151,000*	14.7%
Intelligent Emergency Response System and Infrastructure Market	\$66,700	\$71,700	\$77,100	\$82,900	\$89,200	\$95,900	7.5%
Risk Analytics Market	\$14,400	\$16,600	\$18,700	\$21,000	\$23,700	\$26,800	13.2%

Market Highlights

Improved Standoff Detection and Identification of Multiple Hazards

Improved Standoff Detection and Identification of Multiple Hazards focuses on the initial detection of hazardous agents and characterization of critical information. In order to improve the safety, efficiency and effectiveness of response personnel, responders need sensors or solutions that measure the quantity, volume and concentration of threats and hazards at an incident scene. Responders are often exposed to multiple threats and hazards during an incident, such as caustic gases and volatile organic compounds (VOCs), radioactive contamination, biological agents, deficient oxygen levels, as well as explosive and secondary devices. The ability to detect, characterize and measure threats and hazards will likely provide a reliable basis for making time-sensitive decisions that can affect the health of responders and the public.



PRIMARY MARKET
Threat Detection
Systems Market

Current Capability:

Responders often use multiple sensors and detectors to identify hazardous agents and contaminants, including personal radiation detectors (PRDs), multi-gas chemical detectors, infrared sensors, medical infection control sensors and motion detectors. However, procurement and deployment of these devices often varies depending on responder jurisdiction and discipline.

Market Quantification

Market Size (2015): \$48.4 Billion

Compound Annual Growth Rate
(2015-2020): 13.7%

Competitive Landscape

Number of Global Key
Market Players: 11

Number of Responder-Specific
Existing Solutions: 10

Number of Responder-Specific
R&D Initiatives: 11

Dominant Solution

Spectroscopy Equipment
Systems

Defined: Systems equipped with spectroscopy capabilities identify matter or particles using an electromagnetic spectrum. These solutions are used for various applications, including chemical, biological, radiological, nuclear and explosives (CBRNE) identification at close or standoff distances.

Market Factors

OPPORTUNITIES

Real-time detection and identification of chemical, biological, radiological and explosive particles

Increasing demand for automated systems requiring less human intervention

Multi-sensor integration and analysis

Market Phase

MATURE + GROWTH

BARRIERS

The size, weight and cost of sensors often increases, and performance degrades as standoff distance is extended

False positives and negative rates may lead to distrust and disuse of technology

Market Highlights

Multi-Sensor Integration and Analysis

Multi-Sensor Integration and Analysis focuses on the integration and miniaturization of sensors in order to deploy technology on a smaller number of platforms and integrate analysis capabilities for enhanced situational awareness, which may include a comprehensive picture of hazards at an incident scene. In order to improve the safety, efficiency and effectiveness of response personnel, responders need the ability to assess their current level of risk from multiple threats.



Current Capability:

Responders often carry multiple types of sensors on their person as part of their PPE, in their hands or deployed on an apparatus (e.g., radiation pagers, five-gas meters) to assess risk during an incident. Command staff also rely on measurements from multiple types of fixed and mobile sensors deployed on various platforms to support risk-related decision-making. However, data from these sensors is often not integrated, and analysis of the results is done individually. Therefore, the ability to deploy sensors on fewer platforms with analysis capabilities will likely help incident response efforts at all levels.

Market Quantification

Market Size (2015): \$18.6 Billion

Compound Annual Growth Rate (2015-2020): 17.6%

Competitive Landscape

Number of Global Key Market Players: 16

Number of Responder-Specific Existing Solutions: 18

Number of Responder-Specific R&D Initiatives: 2

Dominant Solution

Microelectromechanical Systems (MEMS)-based Sensors

Defined: MEMS integrate mechanical and electrical components into a wide range of systems, such as smart sensors. MEMS components may range in sizes from micrometers to millimeters, which enables systems to be miniaturized and equipped with multiple components.

Market Factors

OPPORTUNITIES

Compact size, reduced power consumption, lower cost and increased reliability
 Increasing use of smart sensors in various end-user industries
 Growing trend of miniaturization in electronics
 Deployment on multiple platforms (e.g., manned and unmanned ground and aerial vehicles)

Market Phase

MATURE + GROWTH

BARRIERS

Interoperability with common electronic situational awareness tools, including a common hub or interface
 Limited commercial advantage in a standardized plug or hub; a proprietary interface is likely to be more advantageous

Figures for Competitive Landscape are not all encompassing; it is likely that additional firms and solutions exist.

Market Highlights

Risk Assessment and Decision Support to Command

Risk Assessment and Decision Support to Command focuses on the development of a decision support system that can analyze pertinent data and provide reliable information to command staff to make informed decisions regarding responder and public safety. In order to improve the safety, efficiency and effectiveness of response personnel, command staff need a decision support system that will improve their understanding of the threats and hazards on the incident scene and support accurate decision-making. In addition, the sensors and imaging systems involved in the identification, characterization and monitoring of threats and hazards may produce large amounts of technical data and require analysis of complex information. Therefore, an increase understanding of pertinent data and information facilitated by a decision support system, will likely allow command staff at all levels to make appropriate decisions for responders during an incident.



Current Capability:

First responders often collect information from multiple sources on a variety of platforms to improve situational awareness and decision-making capabilities. Notably, advanced decision support systems appear to be emerging within the emergency response community due to advances in digital interface technology and Command and Control defense systems.

Market Quantification

Market Size (2015): \$17.9 Billion

Compound Annual Growth Rate (2015-2020): 9%

Competitive Landscape

Number of Global Key Market Players: 19

Number of Responder-Specific Existing Solutions: 8

Number of Responder-Specific R&D Initiatives: 5

Dominant Solution

Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) Systems

Defined: Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) Systems provide added situational awareness and decision support to defense-related missions and incident response scenarios.

Market Factors

OPPORTUNITIES

C2/C4ISR Systems technology dual-use in defense and public safety applications

Increasing need of situational awareness among multiple industry verticals (e.g., border security, private security)

Deployment of land, space, naval and airborne systems

Increasing demand for mobile command systems

Market Phase

MATURE + GROWTH

BARRIERS

Decrease in military spending in developed nations

Quality and accuracy of information

Liability concerns

Interoperability

Market Factors

The ability to rapidly identify hazardous agents and contaminants:



Improved Standoff
Detection and
Identification of
Multiple Hazards

Market Opportunities

- ✓ Real-time detection and identification of chemical, biological, radiological and explosive particles
- ✓ Increasing demand for automated systems requiring less human intervention
- ✓ Multi-sensor integration and analysis

Market Barriers

- x The size, weight and cost of sensors often increases, and performance degrades as standoff distance is extended
- x False positives and negative rates may lead to distrust and disuse of technology



Multi-Sensor Integration
and Analysis

Market Opportunities

- ✓ Compact size, reduced power consumption, lower cost and increased reliability
- ✓ Increasing use of smart sensors in various end-user industries
- ✓ Growing trend of miniaturization in electronics
- ✓ Deployment on multiple platforms (e.g., manned and unmanned ground and aerial vehicles)

Market Barriers

- x Interoperability with common electronic situational awareness tools, including a common hub or interface
- x Limited commercial advantage in a standardized plug or hub; a proprietary interface is likely to be more advantageous



Risk Assessment and
Decision Support to
Command

Market Opportunities

- ✓ C2/C4ISR Systems technology dual-use in defense and public safety applications
- ✓ Increasing need of situational awareness among multiple industry verticals (e.g., border security, private security)
- ✓ Deployment of land, space, naval and airborne systems
- ✓ Increasing demand for mobile command systems

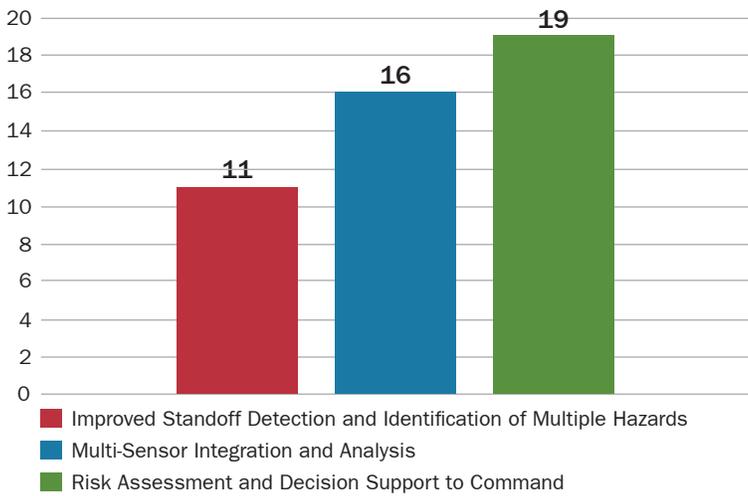
Market Barriers

- x Decrease in military spending in developed nations
- x Quality and accuracy of information
- x Liability concerns
- x Interoperability

Competitive Landscape

A total of 46 firms were recognized as key global market players within the primary markets of Capability Gap 3. Specifically, the breakdown of each market is as follows:

**Rapid Identification of Hazardous Agents and Contaminants:
Key Global Market Players in the Primary Markets**



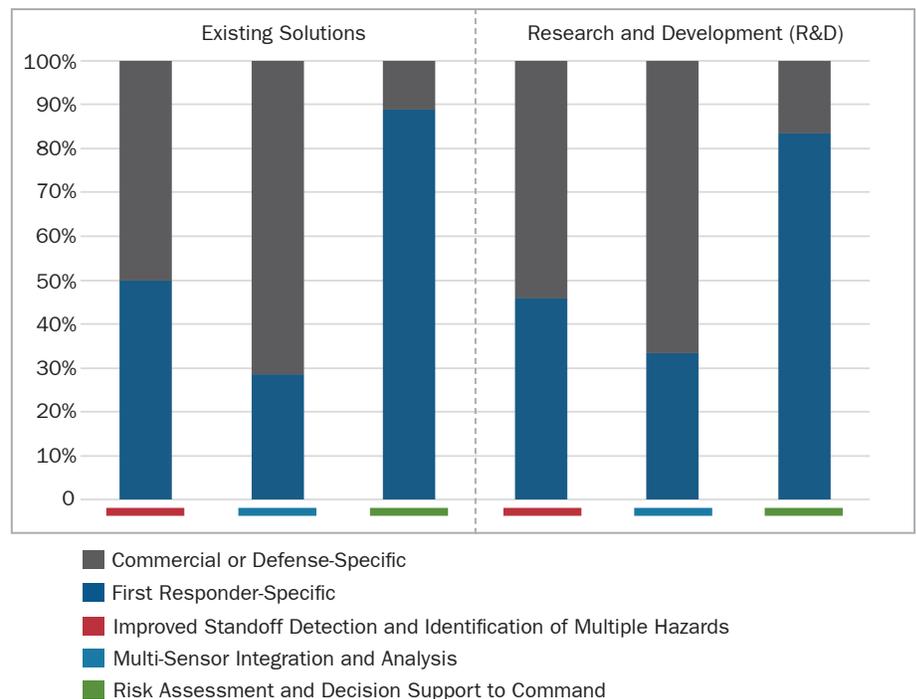
The following three firms were identified as key global market players in each market segment relevant to Capability Gap 3, the ability to rapidly identify hazardous agents and contaminants:

General Electric Corporation (U.S.);
Honeywell International Inc. (U.S.); and
Lockheed Martin Corporation (U.S.).

This analysis activity has identified a total of 92 existing solutions and 36 research and development (R&D) initiatives related to Capability Gap 3 - The Ability to Rapidly Identify Hazardous Agents and Contaminants.

Among the existing and developing solutions identified, 36 solutions (39.1 percent) appear to be readily deployable for first responder use and 18 solutions (50 percent) appear to be in development for first responder use.

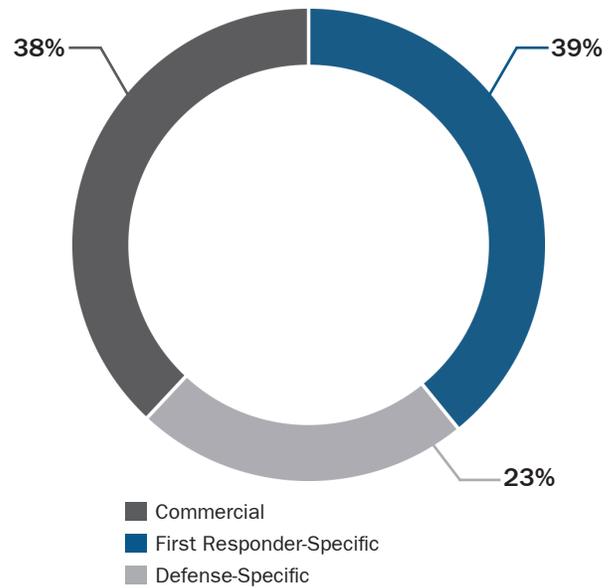
Technology Landscape Summary



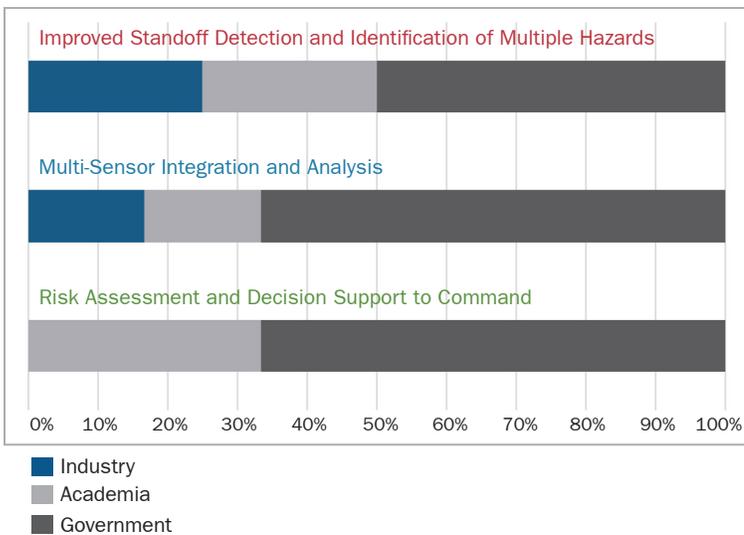
The greatest number of existing solutions (39 percent) identified by this analysis activity appear to be designed for first responder use, while 38 percent of solutions appear to be designed for use in various commercial industries and 23 percent of solutions appear to be designed for defense-related initiatives.

There may be an opportunity for firms with existing commercial solutions to compete in the first responder market by adapting existing solutions to meet the needs of first responders.

Existing Solutions by Sector—
Commercial, First Responder-Specific, Defense-Specific



Research and Development (R&D) by Sector—
Industry, Academia and Government:



This analysis activity identified 36 R&D initiatives related to Capability Gap 3 - The Ability to Rapidly Identify Hazardous Agents and Contaminants.

Among the developing solutions identified, 20 solutions (55.6 percent) appear to be initiated by government organizations, 9 solutions (25 percent) appear to be initiated by academic institutions and 7 solutions (19.4 percent) appear to be initiated by industry firms.

Based upon the data presented, there is a comparatively low number of responder-specific solutions identified, given the number of firms operating in each segment. This presents an opportunity for those firms already developing solutions in the broader market, as in some cases they may be able to make slight adaptations to existing solutions to meet first responder needs. By engaging with responders, particularly on a global level through the Forum, firms can begin to assess how close they are to providing meaningful solutions for responders. Furthermore, they can engage responders throughout their process to ensure that their developments will meet responder needs.

For questions or comments related to the information presented in this assessment, please contact the Forum at info@internationalresponderforum.org.

First Responder-Specific Technologies:

The following section presents some of the potential first responder-specific solutions by segment as identified by this assessment. It is likely that there are additional potential solutions that exist or are in development and therefore, this section should not be considered exhaustive. A complete list of solutions identified by this assessment can be found in the Appendix at the end of this synopsis.

The data presented in this section represents information that is publicly available from manufacturers' Web sites. This information is not further validated by this assessment.

Improved Standoff Detection and Identification of Multiple Hazards

ChemImage Sensor Systems (CISS)

ChemImage Sensors Systems (CISS) (United States) develops standoff chemical imaging sensors for drug, chemical, biological and explosive (CBE) threats. CISS states it has developed a series of chemical imaging sensors for point, proximity, remote and standoff detection and identification in both fixed site and moving configurations to improve the safety of military troops, security personnel and the public. CISS appears to offer two standoff detection solutions that can be deployed for first responder use.

CISS states LightGuard™ provides real-time standoff detection of explosives, chemical threats and narcotics on the surfaces of vehicles, personnel and other items. LightGuard™ deploys short-wave infrared (SWIR) hyperspectral imaging (HIS) supported by liquid crystal tunable filter technology and detection software. CISS states some of the key features of LightGuard™ include the following:

- Real-time, wide area imaging
- 7 to 50 meter standoff detection and screening capabilities
- Automated, reagentless detection
- Customizable threat signature library
- Easy-to-use software interface

CISS states VeroVision Stationary Threat™ is a portable near infrared (NIR) hyperspectral imaging (HIS) sensor that provides real-time, standoff detection capabilities. CISS states some of the key features of VeroVision™ include the following:

- Portable, real-time, wide area imaging;
- 1 to 20 meter standoff detection and screening capabilities;
- Automated, reagentless detection;
- Detects bulk and residue levels of threat materials;
- Detects through plastic and thin fabrics;
- Deployable both indoors and outdoors; and
- Up to five hours of battery-powered operational detection time.



LightGuard™



VeroVision Stationary Threat™

In December 2016, Military & Aerospace Electronics and Intelligence Aerospace awarded CISS with a Platinum Technology Innovation Award for VeroVision™. The award recognizes companies that offer premium military, aerospace and avionics product design solutions.

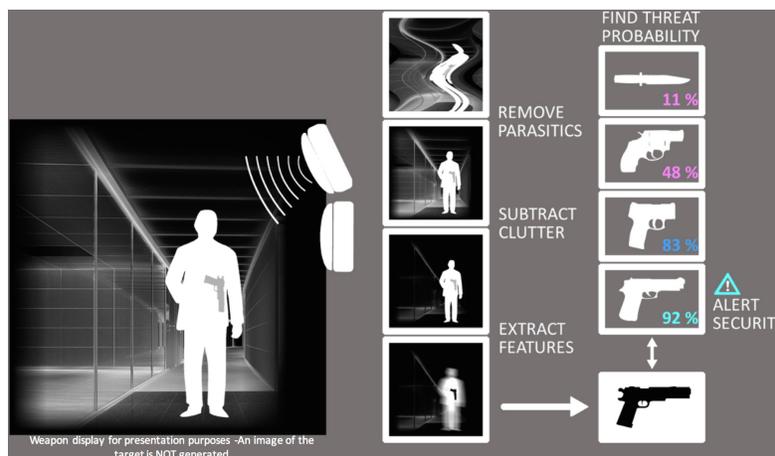
Information regarding price and specific deployment within the first responder community does not appear to be publicly available for these solutions.

Patriot One Technologies Inc.

Patriot One Technologies Inc. (Canada) develops solutions to address the rising need for effective active threat management.

Patriot One states NForce CMR1000 is the first cost-effective solution for active shooter prevention. NForce CMR1000 uses low-power impulse radar technology for standoff detection of concealed threats, such as handguns, knives, grenades and explosive vests. In addition, NForce CMR1000 is paired with a machine learning system that continuously improves its threat assessment capabilities. Its “Cognitive Microwave Radar” concealed weapons detection system is trained prior to installation and continues to learn upon deployment. NForce CMR1000 is placed in concealed locations (e.g., entryways, hallways, stairwells) and provides a two-meter (6.5 feet) detection range. Patriot One states some of the key features of NForce CMR1000 include the following:

- Small enough for covert hall and doorway installations (267mm x 160mm x 44mm);
- Images of the target are not generated, thus no privacy concerns;
- System acquires results on moving targets, thus no subject compliance is required;
- Secured locations are inconspicuous, thus not institutional;
- Time consuming scans are not required;
- Does not require line of sight;
- Compact and lower cost than millimeter-wave units;
- Low cost allows for multiple networked units;
- Weapon profiles are regularly updated network-wide;
- Real-time and entirely computer-based, thus human operators are not required;
- Early detection reduces inspection team size and provides first responders with critical intervention time;
- System “learns” and continuously perfects its detection ability; and
- Frequencies are aligned with international regulations for safe use of microwave bandwidth.



Patriot One NForce CMR1000 Overview

In April 2017, the Security Industry Association (SIA) awarded Patriot One for “Best New Counter Terrorism/Force Protection Product” at the International Security Conference & Exposition. Patriot One is accepting and processing orders for NForce CMR1000. However, delivery and installation of the solution is planned to occur by December 2017. Information regarding price does not appear to be publicly available for this solution.



NForce CMR1000



Multi-Sensor Integration and Analysis

BBI Detection

BBI Detection (United Kingdom) develops and manufactures rapid sampling and identification technologies to detect explosives and bio-threat agents for military, first responder and security personnel.

BBI Detection offers its Integrated Multiplex Assay and Sampling System (IMASS™) platform, that claims to provide a simplistic, robust and ergonomic design for quick and reliable hand held assay and sampling system capabilities. The IMASS™ is available in a Biothreat Detection and Explosive Detection format.

BBI Detection states some of the key features of the Biothreat Detection IMASS™ device include the following:

- Detects up to eight biothreat agents*
- Results in 15 minutes;
- Easy to use in full individual protective equipment;
- Can sample surfaces, powders or liquids;
- No power requirements; and
- No additional collection/dilution kits or readers are required.

*BBI Detection states the IMASS™ device can detect up to eight biothreat agents, which include: (1) Bacillus anthracis, (2) Ricin, (3) Francisella tularensis, (4) Yersinia pestis, (5) Burkholderia mallei, (6) Brucella spp., (7) Botulinum Toxin A and B and (8) Saphylococcal enterotoxin B.



Integrated Multiplex Assay and Sampling System (IMASS™)

BBI Detection states some of the key features of the Explosive Detection IMASS™ device include the following:

- Detects military explosives (i.e., TNT, RDX, PETN and their derivatives);
- Detects homemade explosive components (i.e., ammonium, nitrate and sugar);
- Ergonomic design ensures that it is easy to use in full protective equipment;
- Integrated sampling and assessment;
- Results for all six assays within three minutes;
- Can sample surfaces, powders or liquids;
- No power requirements; and
- Sample retention for subsequent analysis

Notably, BBI Detection states it is developing a solution to detect trace levels of Chemical Warfare Agents (CWAs) to add to its IMASS™ platform. The Technology Readiness Level of this solution does not appear to be publicly available.

In addition, information regarding price and specific deployment within the first responder community for the aforementioned IMASS™ solutions, does not appear to be publicly available.

Morphix Technologies Inc.

Morphix Technologies Inc. (United States) offers colorimetric chemical detection solutions for military, law enforcement, emergency response and industrial personnel.

In 2005, Morphix Technologies launched its Chameleon® product line, which provides rugged, user-friendly chemical detection for military and first response personnel. Chameleon® is a real-time, color-change chemical detection system that can be integrated into personal protective equipment (PPE) or attached to an apparatus, such as an unmanned vehicle. The solution is designed for use in arctic, tropical and desert conditions, and can also be immersed in water (for approximately one hour). Chameleon® has a cassette shelf life of 24 months at room temperature, and a cassette service life of 24 hours.



Morphix Technologies Inc., Chameleon®

In 2013, Morphix Technologies launched its TraceX® product line, which detects trace levels of explosive materials and their precursors including nitroaromatics, nitramines and nitrate ester, inorganic nitrates, chlorates and bromates, peroxides, acids and bases. Similar to Chameleon®, TraceX® is a rugged, user-friendly chemical detection kit for military and first response personnel. Morphix Technologies states some of the key features of TraceX® include the following:

TraceX® Explosives Kit	
Number of Explosive Families Detected in One Test Cycle	9
Trace Detection	Yes
Bulk Detection	Yes
Time for Results	<3 minutes total
Ease of Use	Single swab and crush
Interpretation of Results	Results clearly indicated
User Safety	All chemicals contained inside plastic case
Potential for Sample Contaminant	Low
Ruggedness	Each kit encased in protective plastic case
Heat Source Required	No

Information regarding price and specific deployment within the first responder community does not appear to be publicly available for these solutions.



Risk Assessment and Decision Support to Command

AlphaTRAC Inc.

AlphaTRAC Inc. (United States) provides decision-oriented planning, preparedness and training solutions for multiple public safety application areas, such as emergencies involving chemical, biological, radiological, nuclear and explosive hazards, fireground management, law enforcement and disaster management.

AlphaACT® platform for crisis decision training is composed of multiple applications that feature a particular incident response. According to AlphaTRAC, the platform uses pattern recognition engines, graphical user interfaces and a database of scenarios to train users to apply past experiences to rapidly changing crisis conditions. The AlphaACT platform of training applications include the following:

AlphaACT® FIRE – AlphaACT® FIRE is described as a web-based training solution that helps fireground incident commanders build their decision-making skills under time pressure and uncertainty constraints.

Annual AlphaACT® FIRE subscription cost:

Single User	\$50.00
Shift-level Bundle (5 Users)	\$295.00
Station-level Bundle (15 Users)	\$495.00

AlphaACT® HAZMAT – AlphaACT® HAZMAT is described as a web-based, crisis decision training solution designed to help emergency responders build their skills in decision-making for hazardous chemical emergencies.

AlphaACT® U.S. Marine Corps (USMC) – AlphaACT® USMC is currently under development. However, AlphaTRAC describes the solutions as a web-based training tool that may help U.S. Marine Corps small unit leaders to enhance their decision-making skills for asymmetric warfare.

In addition to the solutions mentioned above, AlphaTRAC states it plans to develop applications for law enforcement, medical, emergency management and military service environments. Information regarding price and specific deployment within the first responder community does not appear to be publicly available for these solutions.



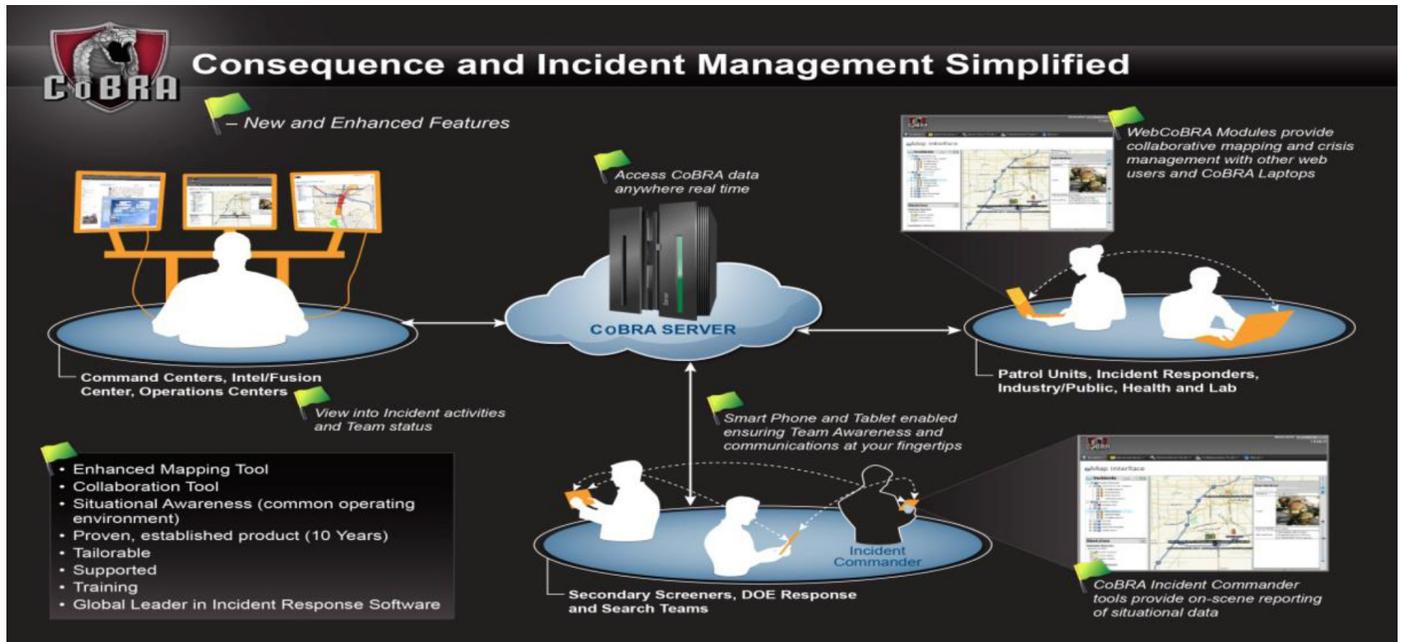
AlphaACT® FIRE

Cobra Software Group LLC

Cobra Software Group LLC (United States) offers a multi-platform, enterprise level solution, designed to address all hazards, stages of emergency management and levels of emergency response.

The CoBRA Emergency Management Information System platform provides emergency management organizations with features and capabilities needs to manage multiple types of crises. Cobra Software states some of the key features of CoBRA include the following:

- **Common Operating Picture** including real-time, collaborative mapping across mobile laptop and web platforms;
- **Emergency Management Software** features provide a complete toolset for all operational levels of crisis management, from tactical field responder to the emergency operations center;
- **Decision Support Tool** provides rapid threat assessment for hazardous materials, explosives threats, chemical and biological hazards and weapons, nuclear and radiological threats;
- Multi-device family enables access to CoBRA software from any device, at any time;
- Unlimited attachments of photos, videos and documents supports enhanced communication capabilities; and
- CoBRA functions without internet connectivity, allowing mobile first responders to utilize a cache and carry emergency response system.



CoBRA® Emergency Management and Mapping Solution

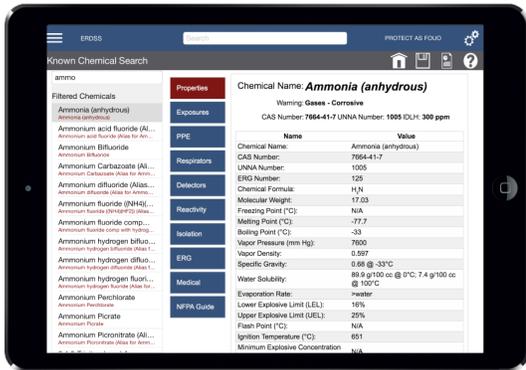
In addition to the main operating system, Cobra Software states some of the key features of the **CoBRA Decision Support Tools** include the following:

- Identify hazards and isolate the area with unique plume modeling tools;
- Quickly review extensive reference libraries and interactive tools;
- Deny entry by providing safe standoff distances, calculate radiological exposure limits, explosive effects and downwind hazard zones;
- Access pre-planned action plans and use the Incident Action Planning tool to dynamically create an Incident Action Plan (IAP) from integrated Incident Command System (ICS) forms, custom forms and incident data; and
- Supports national standards such as the National Incident Management Systems (NIMS) and ICS.

Information regarding price and specific deployment within the first responder community does not appear to be publicly available for this solution.

Georgia Tech Research Institute

Georgia Tech Research Institute (United States) developed the Emergency Response Decision Support System (ERDSS) or “Chemical Companion,” to provide first responders with a decision support and situational analysis tool for hazardous environments. The software tool currently operates on Windows and iOS devices, and is free to use for military, law enforcement and fire service personnel. Georgia Tech Research Institute states some of the key features of Chemical Companion include the following:



Chemical Companion

- Detailed information on 2,000 common chemicals and synonyms;
- Personal Protective Equipment (PPE) including respirators;
- Hazardous concentration levels and exposure guidelines;
- Isolation and protective action distances;
- ERG and emergency medical information;
- Identification of unknown chemicals using physical properties or exposure systems; and
- Decision support tools.

The Chemical Companion is available for use in the U.S. and partnering countries. Information regarding specific deployment within the first responder community does not appear to be publicly available for this solution.

Appendix

The following section includes tables that list the potential first responder-specific solutions, both existing and in development, as identified in this assessment. It is likely that there are additional potential solutions in the market and therefore, this section should not be considered exhaustive.

Improved Standoff Detection and Identification of Multiple Hazards

Existing Solutions	
Industry, Academia and Government	Solution
Bertin Instruments	Second Sight MS
	Coriolis Recon
ChemImage Sensor Systems (CISS)	Eye-Safe Standoff Fusion Detection (ESFD) Sensor
	LightGuard™
	VeroVision Stationary Threat™
Chemring Group plc	I-Collector
	I-SCAD® Standoff Chemical Agent Detector® (I-SCAD)
Patriot One Technologies Inc.	NForce CMR1000
Rapiscan Systems	CounterBomber
TeraView Limited	Standoff Explosives Detection System

Developing (R&D) Solutions	
Industry, Academia and Government	Solution
Cubic Global Defense (CGD)	Clear-Use
Department of Homeland Security (DHS) Science and Technology (S&T) Directorate	Detect-to-Protect (D2P)
Homeland Security Advanced Research Projects Agency (HSARPA)	ChemTag
	Cell-All
Institute of Technical Physics at the Germany Aerospace Center (DLR)	Standoff Aerosol Classification
LGS Innovation	Real-time Standoff Active Infrared Spectroscopy
Texas A&M University	Single-shot Standoff Chemical Identification of Powders
University of Hawaii	Standoff Raman Chemical Detection System
	Standoff Biofinder
University of Maryland	Standoff Quantum Cascade Laser Chemical Detector
U.S. Naval Research Laboratory	Photo-Thermal Infrared Imaging Spectroscopy

Multi-Sensor Integration and Analysis

Existing Solutions	
Industry, Academia and Government	Solution
908 Devices Inc.	M908™
BBI Detection	IMASS™ Device
Chemring Group plc	PGR-1064™
Cobalt Light Systems Ltd.	Resolve™
Honeywell International Inc.	ChemKey TLD Toxic Gas Detector
FLIR Systems Inc.	Fido X2
	Fido X3
	Fido X80
	identiFINDER R400
	Agentase C2
Morphix Technologies Inc.	Chameleon® Chemical Detection Armband
	TraceX® Explosive Detection Kit
RAE Systems by Honeywell International Inc.	Colorimetric Gas Detection Tubes and Pump
	MultiRAE
Smiths Detection	GasID
Thermo Fisher Scientific Inc.	FirstDefender RM
	Gemini Handheld Analyzer
	TruDefender

Developing (R&D) Solutions	
Industry, Academia and Government	Solution
RIEGL Laser Measurement Systems GmbH	UAV-based Multi-Sensor System
University of Utah	Carbon Nanotube Material for Handheld Sensors

Risk Assessment and Decision Support to Command

Existing Solutions	
Industry, Academia, Government	Solution
Alluviam LLC	HazMasterG3
AlphaTRAC Inc.	AlphaACT®
Applied Research Associates Inc.	First Responder Support Tools (FiRST) Application
Cobra Software Group LLC	CoBRA Emergency Management Information System Platform
Georgia Tech Research Institute	Emergency Responder Decision Support System (ERDSS) aka Chemical Companion
International Business Machines (IBM) Corporation	IBM Intelligent Operations Center for Emergency Management
PDC-ARGOS Aps	ARGOS (CBRN Crisis Management)
RAE Systems by Honeywell International Inc.	ConneXt Pack

Developing (R&D) Solutions	
Industry, Academia, Government	Solution
National Aeronautics and Space Administration (NASA) Jet Propulsion Lab	First Responder Artificial Intelligence
U.S. Army Research Laboratory	Local-Rapid Evaluation of Atmospheric Conditions (L-REAC)
University College Cork	Decision-Support System for Multi-Agency Decision-Making During Cross-Border Emergencies
University of Pittsburgh	I-Corps: Dynamic Decision Support for Emergency Managers
U.S. Geological Survey (USGS) Western Geographic Science Center	Decision-Support Systems for Natural-Hazards and Land-Management Issues

Market Figure Disclaimers

RTO: Improved Standoff Detection and Identification of Multiple Hazards

Biodefense Market—the Biodefense Market forecast period is 2015 to 2025 with market figures available for 2015 and 2025. The CAGR of 6.4 percent was used to estimate the revenue values for 2014 to 2020.

Biodefense-Related Rapid Pathogen Identification and Treatments (U.S.) Market—the Biodefense-Related Rapid Pathogen Identification and Treatments (U.S.) Market forecast period is 2016 to 2021 with market figures available for 2015, 2016 and 2021. The CAGR of 8 percent was used to estimate the revenue values for 2017 to 2020.

The *detection devices market segment* forecast period is 2016 to 2021 with market figures available for 2016 and 2021. The CAGR of 5.2 percent was used to estimate the revenue values for 2015 and 2017 to 2020. The figure for 2015 was extrapolated outside the forecast period.

The *sensors devices market segment* forecast period is 2016 to 2021 with market figures available for 2016 and 2021. The CAGR of 12 percent was used to estimate the revenue values for 2015 and 2017 to 2020. The figure for 2015 was extrapolated outside the forecast period.

Chemical, Biological, Radiological, Nuclear and Explosives (CBRNE) Detection Market—the CBRNE Detection Market forecast period is 2015 to 2020 with market figures available for 2015 and 2020. The CAGR of 34.8 percent was used to estimate the revenue values for 2014 to 2019.

Chemical Sensors—the Chemical Sensors Market forecast period is 2015 to 2020 with a market figure available for 2018. The CAGR of 7.6 percent was used to estimate the revenue values for 2015 to 2017 and 2019 to 2020.

Digital Scent Technology Market—the Digital Scent Technology Market forecast period is 2014 to 2020 with market figures available for 2014 and 2020. The CAGR of 28.2 percent was used to estimate the revenue values for 2015 to 2019.

Threat Detection Systems Market—the Threat Detection Systems Market forecast period is 2015 to 2022 with market figures available for 2015 and 2022. The CAGR of 13.7 percent was used to estimate the revenue values for 2014 to 2020.

Explosive Detectors Market—the Explosive Detectors Market forecast period is 2015 to 2020 with market figures available for 2015 and 2020. The CAGR of 11.4 percent was used to estimate the revenue values for 2016 to 2019.

Infrared (IR) Spectroscopy Market—the IR Spectroscopy Market forecast period is 2015 to 2020 with a market figure available for 2020. The CAGR of 6.9 percent was used to estimate the revenue values for 2015 to 2019.

Portable Gas Detectors Market—the Portable Gas Detectors Market forecast period is 2015 to 2021 with market figures available for 2015 to 2021. The CAGR of 4.1 percent was used to estimate the revenue values for 2016 to 2020.

The *fire services market segment* forecast period is 2015 to 2021 with market figures available for 2015 and 2021. The CAGR of 8.9 percent was used to estimate the revenue values for 2016 to 2020.

Raman Spectroscopy Market—the Raman Spectroscopy Market forecast period is 2016 to 2021 with market figures available for 2016 and 2021. The CAGR of 10.2 percent was used to estimate the revenue values for 2015 and 2017 to 2020. The figure for 2015 was extrapolated outside the forecast period.

Spectroscopy Equipment Market—the Spectroscopy Equipment Market forecast period is 2015 to 2020 with market figures available for 2015 to 2020. The CAGR of 2.9 percent was used to estimate the revenue values for 2016 to 2019.

Terahertz Spectroscopy Market—the Terahertz Spectroscopy Market forecast period is 2015 to 2020 with market figures available for 2015 and 2020. The CAGR of 21.3 percent was used to estimate the revenue values for 2016 to 2019.

Volatile Organic Compound (VOC) Gas Detectors Market—the VOC Gas Detectors Market forecast period is 2016 to 2021 with market figures available for 2016 and 2021. The CAGR of 3.3 percent was used to estimate the revenue values for 2015 and 2017 to 2020. The figure for 2015 was extrapolated outside the forecast period.

The *active collection market segment* forecast period is 2016 to 2021 with market figures available for 2015 and 2021. The CAGR of 3.4 percent was used to estimate the revenue values for 2015 and 2017 to 2020. The figure for 2015 was extrapolated outside the forecast period.

The *passive collection market segment* forecast period is 2016 to 2021 with market figures available for 2015 and 2021. The CAGR of 3.3 percent was used to estimate the revenue values for 2015 and 2017 to 2020. The figure for 2015 was extrapolated outside the forecast period.

RTO: Multi-Sensor Integration and Analysis

Microelectromechanical Systems (MEMS) Market—the MEMs Market forecast period is 2014 to 2020 with market figures available for 2014, 2015 and 2020. The CAGR of 11.3 percent was used to estimate revenue values for 2016 to 2019.

Microsensor Market—the Microsensor Market forecast period is 2015 to 2020 with market figures available for 2014, 2015 and 2020. The CAGR of 11.6 percent was used to estimate revenue values for 2016 to 2019.

The *MEMS sensors market segment* forecast period is 2015 to 2020 with market figures available for 2015 and 2020. The CAGR of 8.4 percent was used to estimate revenue values for 2016 to 2019.

The *biochips market segment* forecast period is 2015 to 2020 with market figures available for 2015 and 2020. The CAGR of 16.8 percent was used to estimate revenue values for 2016 to 2019.

Multi-Sensor Market—the Multi-Sensor Market forecast period is 2013 to 2018 with a market figure available for 2018. The CAGR of 7 percent was used to estimate the revenue values for 2015 to 2017 and 2019 to 2020. The market figures for 2019 and 2020 were extrapolated outside the forecast period.

Nanosensors Market—the Nanosensors Market forecast period is 2014 to 2021 with market figures available for 2014 and 2021. The CAGR of 77.6 percent was used to estimate revenue values for 2015 to 2020.

Sensors for the Internet of Things (IoT) Market—the Sensors for the IoT Market forecast period is 2015 to 2022 with market figures available for 2015 and 2022. The CAGR of 41.8 percent was used to estimate revenue values for 2016 to 2020.

Smart Sensors Market—the Smart Sensors Market forecast period is 2015 to 2022 with market figures available for 2015 and 2022. The CAGR of 17.6 percent was used to estimate the revenue values for 2016 to 2020.

RTO: Risk Assessment and Decision Support to Command

Command and Control (C2) Market—the C2 Market forecast period is 2015 to 2020 with market figures available for 2015 and 2020. The CAGR of 3.7 percent was used to estimate the revenue values for 2016 to 2019.

Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) Market—the C4ISR Market forecast period is 2016 to 2021 with market figures available for 2016 and 2021. The CAGR of 3.4 percent was used to estimate the revenue values for 2015 and 2017 to 2020. The market figure for 2015 was extrapolated outside the forecast period.

Command, Control and Intelligence (C2/C4ISR) Market—the C2/C4ISR Market forecast period is 2011 to 2021 with market figures available for 2011 and 2021. The CAGR of 3 percent was used to estimate the revenue values for 2015 to 2020.

First Responder C3I and Emergency Response Market—the First Responder C3I and Emergency Response Market forecast period is 2012 to 2019 with market figures available for 2012 and 2019. The CAGR of 14.7 percent was used to estimate the revenue values for 2015 to 2018 and 2020. The market figure for 2020 was extrapolated outside the forecast period.

Intelligent Emergency Response System and Infrastructure Market—the Intelligence Emergency Response System and Infrastructure Market forecast period is 2015 to 2020 with a market figures available for 2020. The CAGR of 7 percent was used to estimate the revenue values for 2015 to 2019.

Risk Analytics—the Risk Analytics Market forecast period is 2016 to 2021 with market figures available for 2015 and 2021. The CAGR of 12.8 percent was used to estimate the revenue values for 2016 and 2017 to 2020. The market figure for 2015 was extrapolated outside the forecast period.

Situational Awareness Systems Market—the Situational Awareness Systems Market forecast period is 2016 to 2022 with a market figure available for 2022. The CAGR of 8.2 percent was used to estimate the revenue values for 2015 and 2017 to 2020. The market figure for 2015 was extrapolated outside the forecast period.

Glossary

Compound Annual Growth Rate (CAGR)

The average annual growth rate when compounding is taken into account; its formula is as follows:

$CAGR = (FV/PV)^{(1/n)} - 1$, where FV is the future or ending value, PV is the present or starting value and n is the number of years between PV and FV.

First Responder

A person among those responsible for going immediately to the scene of an accident or emergency to provide assistance. The first responder market is to include law enforcement, fire services and emergency medical services.

Project Responder 4 (PR4)

The fourth in a series of studies that commenced in 2003 to focus on identifying capability needs, shortfalls and priorities for catastrophic incident response in the United States. Findings, including a set of enduring and emerging capability needs, technology objectives and state of science and technology to meet capability needs, are based on discussions with federal, state and local first responders as well as technical subject matter experts (SMEs).

Response Technology Objective (RTO)

A term used within Project Responder 4 (PR4) to translate a capability statement into an actionable, technology-centric objective.

Improved Standoff Detection and Identification of Multiple Hazards

This RTO focuses on the initial detection of hazardous agents and characterization of critical information, rather than the ongoing surveillance and monitoring of threats and hazards. In order to improve the safety, efficiency and effectiveness of response personnel, responders need sensors or solutions that measure the quantity, volume and concentration of threats and hazards at an incident scene. Responders are often exposed to multiple threats and hazards during an incident, such as caustic gases and volatile organic compound (VOCs), radioactive contamination, biological agents, deficient oxygen level and explosive and secondary devices. The ability to detect, characterize and measure threats and hazards will likely provide a reliable basis for making time-sensitive decisions that can affect the health of responders and the public.

Multi-Sensor Integration and Analysis

This RTO focuses on the integration and miniaturization of sensors in order to deploy the technology on a smaller number of platforms and integrate analysis capabilities to provide enhanced situational awareness, which may include a comprehensive picture of hazards at an incident scene. In order to improve the safety, efficiency and effectiveness of response personnel, responders need the ability to assess their current level of risk from multiple threats. Responders often carry multiple types of sensors on their person as part of their PPE, in their hands or deployed on an apparatus (e.g., radiation pagers, five-gas meters), to assess risk during an incident. Command staff also rely on measurements from multiple types of fixed and mobile sensors deployed on various platforms to support risk-related decision-making. However, data from these sensors is often not integrated, and analysis of the results is done individually. Therefore, the ability to deploy sensors on fewer platforms with analysis capabilities will likely help incident response efforts at all levels.

Risk Assessment and Decision Support to Command

This RTO focuses on the development of a decision support system that can analyze pertinent data and provide reliable information to command staff to make informed decisions regarding responder and public population safety. In order to improve the safety, efficiency and effectiveness of response personnel, command staff need a decision support system that will improve their understanding of the threats and hazards on the incident scene and support accurate decision-making. According to PR4, the sensors and imaging systems involved in the identification, characterization and monitoring of threats and hazards may produce large amounts of technical data and require analysis of complex information, such as sensor readings, model projections, reporting of conditions from the incident scene and other pertinent information. Command staff often cannot integrate the large amounts of data received or do not have the technical qualifications or training to understand the data and information. This lack of expertise may impede command staff's ability to evaluate the level of risk and make appropriate life-safety or operational decisions during an incident. Therefore, an increase understanding of pertinent data and information facilitated by a decision support system, will likely allow command staff at all levels to make appropriate decisions for responders and the public during an incident.

References

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